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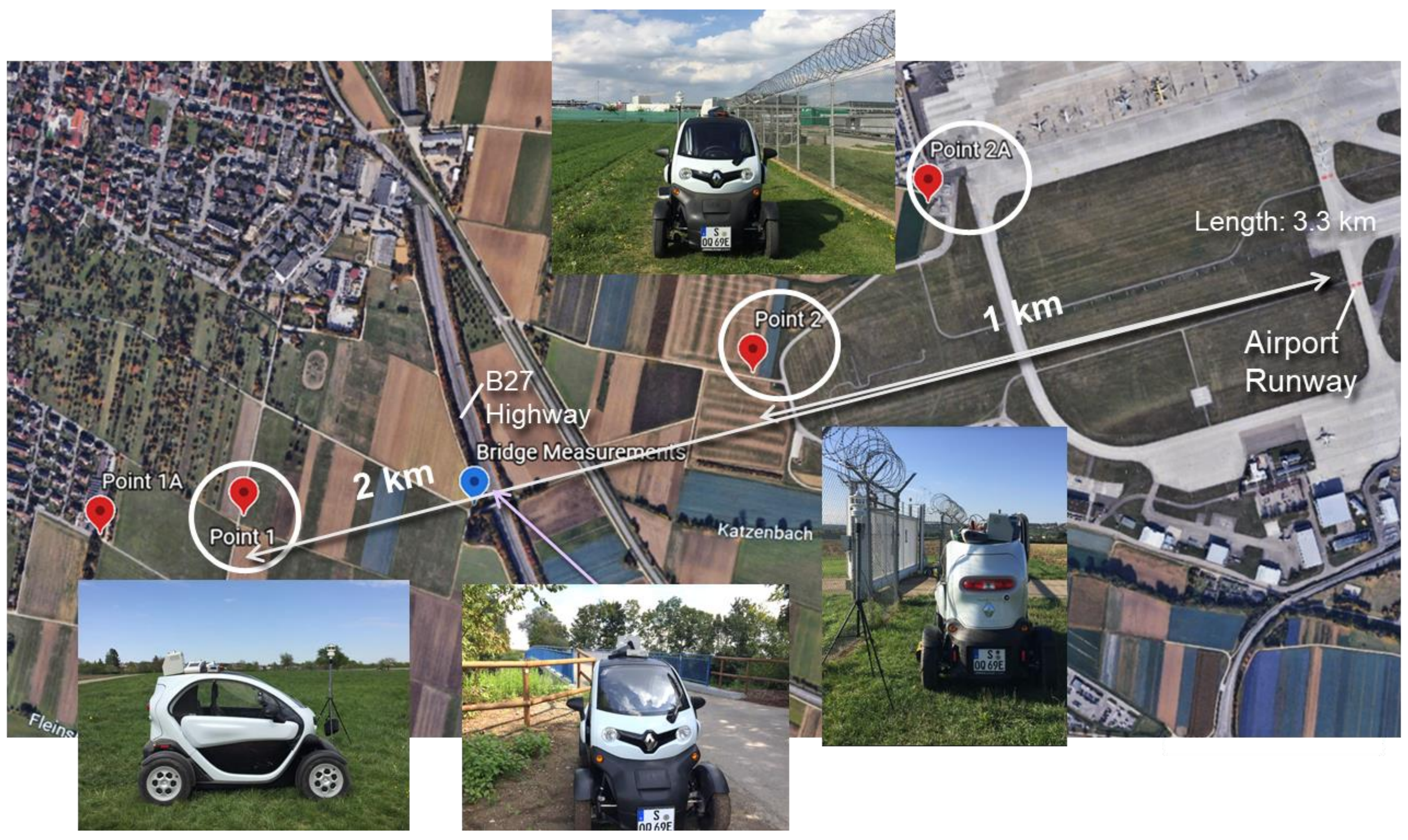
Contribution of Airplane Engine Emissions on the Local Air Quality around Stuttgart Airport during and after COVID-19 Lockdown Measures

Aim of the study

Previous airport studies conducted in Los Angeles, Amsterdam and other cities have shown that aircraft can significantly increase air pollutant concentrations around the airport and can be measured even at distances of several kilometers. Since the results cannot be directly transferred from one city to another and no comparable measurements were carried out at Stuttgart airport, the aim of the study was to investigate whether increased air pollution levels can be measured at the airport fence and in the immediate vicinity of the airport in Stuttgart. Since there are busy roads in the immediate vicinity of the airport (e.g. A8, B27), it should also be investigated whether the exhaust gas plumes from road traffic and air traffic can be distinguished.

Study area

With 12.7 million passengers (2019) and around 400 flights per day, Stuttgart airport is the 6th largest airport in Germany.



The investigations were carried out in three phases in 2020. The measuring locations were on both sides of the airport, at different distances in a direct extension of the runway. The results presented here focus on locations west of the runway at 1 km (Point 2) and 2 km (Point 1) from the start of the runway. The planes were approaching from the west with easterly winds. In addition, measurements were carried out on a bridge over the busy federal highway B27.

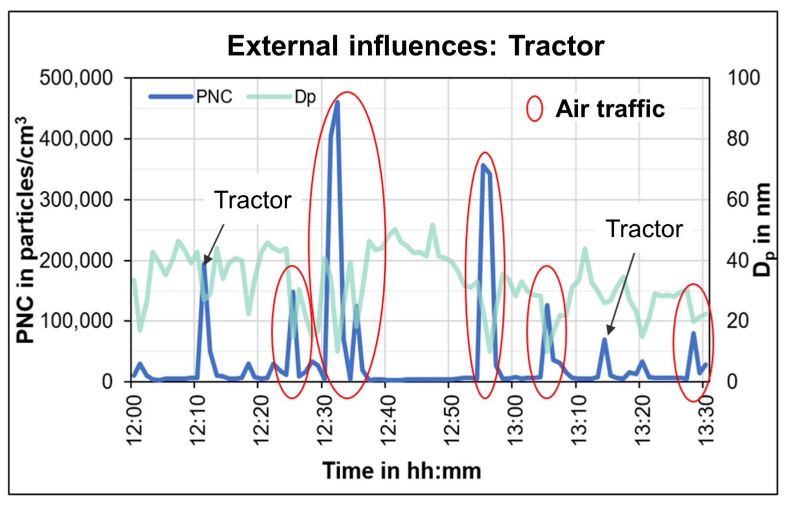
Methodology

The vehicle platform, a Renault Twizy, was equipped with the following measurement technology.

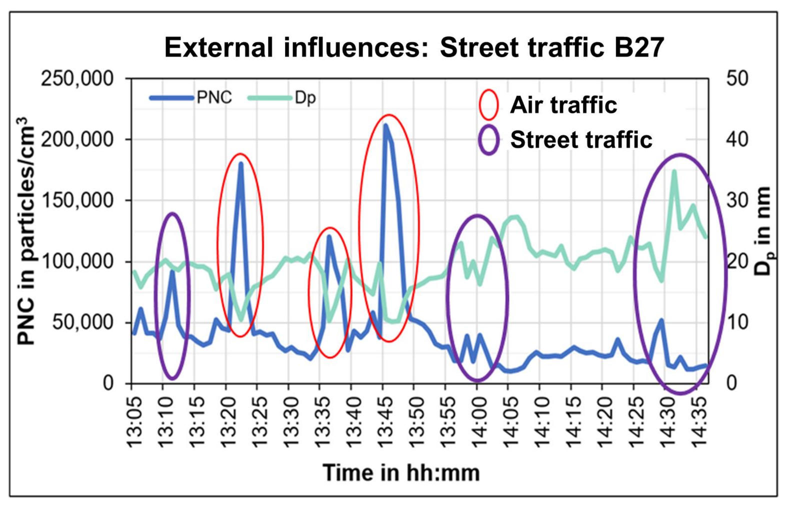
Parameter	Measurement Technique and Principle	Equipment Model	Measurement Range
UFPs + Size Distribution	Scanning mobility particle sizer (SMPS) + Condensation particle counter (CPC) → Particle condensation	NanoScan 3910 (TSI)	10 - 420 nm
UFPs	Diffusion charger (DC) x2	DiSCmini (testo)	10 - 700 nm
UFPs	Condensation particle counter (CPC)	Model 3007 (TSI)	10 - 1000 nm
PM2.5, PM10 + Size Distribution	Optical particle counter (OPC) → Light scattering	OPS 3330 (TSI)	0.3 - 10 µm
PM2.5, PM10 + Size Distribution	Optical particle counter (OPC) → Light scattering	Fidas Frog (Palas)	0.15 - 18 µm
PM2.5, PM10 + Size Distribution	Optical particle counter (OPC) → Light scattering	Model 1.108 (Grimm)	0.3 - 20 µm
BC	Aethalometry → IR and visible light absorption	MA200 (AethLabs)	0 - 1 mg BC/m³
BC	Aethalometry → IR light absorption	AE51 (AethLabs)	0 - 1 mg BC/m³
CO_2	IR absorption	LI-830 (LI-COR)	0 - 20,000 ppm
NO_2 NO	Light absorption	Model 405 nm (2B Technologies)	0 - 10 ppm 0 - 2 ppm
O_3	UV absorption	Ozone Monitor 202 (2B Technologies)	3 ppb - 250 ppm
Wind speed + Direction	Compact weather station	MaxiMet GMX501 (Gill)	-

The runway at Stuttgart airport was renovated at the beginning of the COVID-19 pandemic in April 2020. The airport was therefore closed (**Measurement phase I - mid April 2020**). The airport was then reopened but due to the COVID-19 lockdown measures, very few flights took place (**Measurement phase II - early to mid June 2022**). More flights took place during the 2020 summer holidays, but still the number of flights were around 50% fewer than before the COVID-19 pandemic (**Measurement phase III - mid August to mid September 2020**).

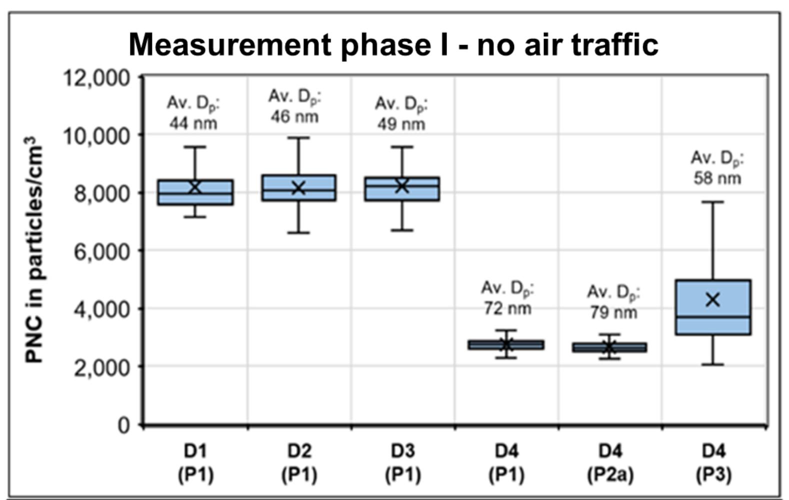
Results

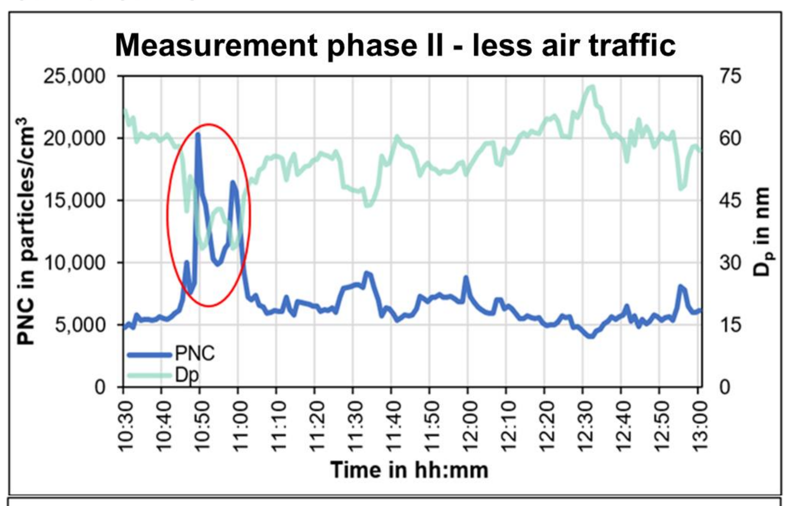


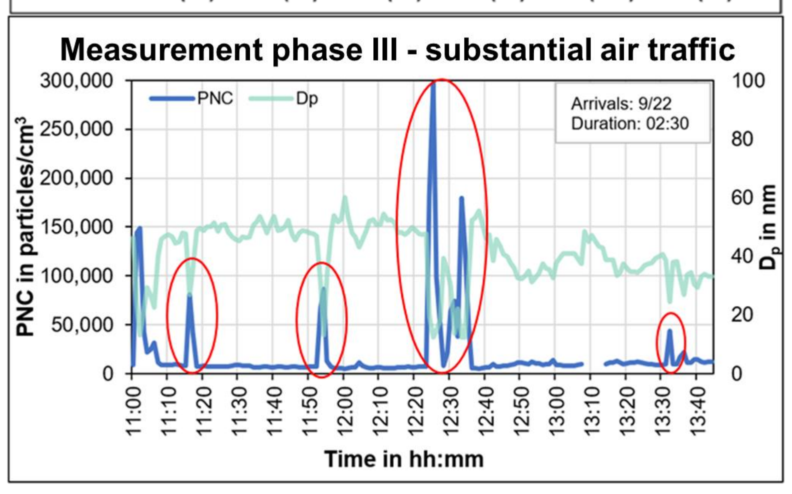
Not only air traffic, but also agricultural traffic, in this case a tractor, generates UFP emissions on the abundant agricultural land around the airport. The peaks from the tractor are marked in the results.

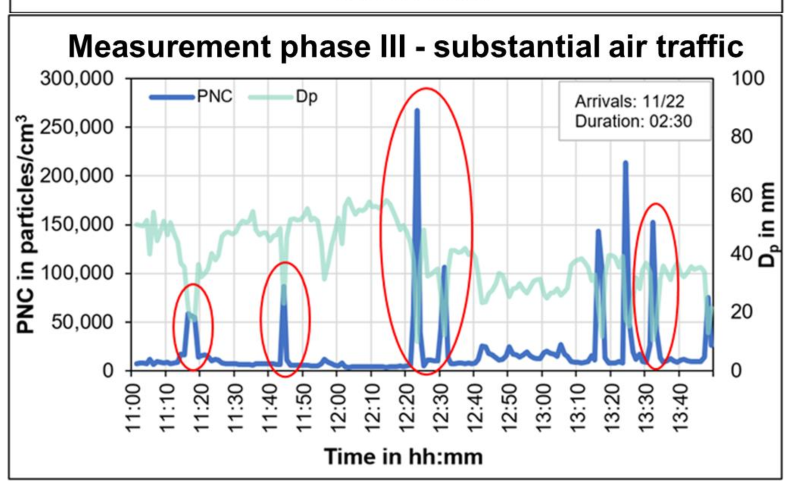


Road traffic also generates UFP emissions. However, the particles are larger than in air traffic, which can be seen from the drop in the average particle diameter D_p to 10 nm when recording the peaks in air traffic.









Measurement phase I - no air traffic: The PNC concentrations were at a low level with values < 10,000 particles/cm³, the mean particle diameter D_p at > 40 nm.

Measurement phase II – less air traffic: Individual peaks from landing aircraft could be recorded. PNC concentrations were > 10,000 particles/cm³ at recorded aircraft peaks.

Measurement phase III – substantial air traffic: Many UFP peaks from landing aircraft could be recorded. They generated PNC peaks of up to 300,000 particles/cm³. During the PNC peaks, the average particle diameter decreased to values between 10 and 20 nm.

Many peaks could be measured both at measuring point 2, directly at the airport fence 1 km away from the runway and at the same time at measuring point 1, around 2 km away from the runway.

Conclusions

Landing planes produced increased concentrations of very fine particles. The mean diameter of the measured particles drops to very low values of 10 to 20 nm.

Peaks were easily measurable even at a distance of 2 km.

Road traffic emissions also produced UFP, but with slightly larger diameters. Hence, UFP can be distinguished from road and air traffic.

Outlook

Mobile measurements should be carried out in adjacent residential areas, also at a greater distance from the airport.

Mobile measurements in combination with long-term measurements should provide information about the exposure of the population to high pollutant concentrations in the vicinity of the airport.

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More information regarding this research can be found in the following publication:

Samad, A.; Arango, K.; Chourdakis, I.; Vogt, U. Contribution of Airplane Engine Emissions on the Local Air Quality Around Stuttgart Airport During and After COVID-19 Lockdown Measures. Atmosphere 2022, 13, 2062. DOI: https://doi.org/10.3390/atmos13122062